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PERCH SITES AND HUNTING BEHAVIOR OF RED-TAILED HAWKS (*BUTEO JAMAICENSIS*)

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ABSTRACT.—For sit-and-wait predators like Red-tailed Hawks (*Buteo jamaicensis*), perch sites are important components of hunting ranges. From October 1999–July 2000, perches (N = 270) used by Red-tailed Hawks in central Kentucky were located and characterized. Perches used by Red-tailed Hawks were relatively high ($\bar{x}$ = 12.3 m) in trees or on poles. Such perches provide a large, relatively unobstructed field of view and likely increase the chances of detecting prey. Red-tailed Hawks spent more time on perches before attacking than before giving up, perhaps waiting to attack prey after locating it to increase the chance of a successful attack. Characteristics of vegetation around perches used by hunting Red-tailed Hawks differed from those of areas around available (but apparently unused) sites during both the breeding and nonbreeding seasons. During the breeding season, areas used by Red-tailed Hawks had less forb cover, lower vegetation density, and shorter vegetation than available areas. During the nonbreeding season, areas used by Red-tailed Hawks were characterized by less bare ground, more grass cover, less shrub cover, fewer small trees, decreased vegetation density, and shorter vegetation than available areas. In general, used areas provided less cover, which may increase prey vulnerability.

KEY WORDS: *Red-tailed Hawk*; Buteo jamaicensis; *giving-up time*; *hunting*; *perch site.*

SITIOS DE PERCHA Y COMPORTAMIENTO DE CAZA DE LOS GAVILANES DE COLA ROJA (*BUTEO JAMAICENSIS*)

RESUMEN.—Para los depredadores que se perchan a esperar sus presas como el gavilán de cola roja (*Buteo jamaicensis*), los sitios de percha son componentes importantes de sus rangos de caza. Desde octubre de 1999 a Julio 2000, se localizaron y caracterizaron las perchas (N = 270) usadas por los gavilanes de cola roja en Kentucky central. Las perchas usadas por los gavilanes de cola roja fueron relativamente altas ($\bar{x}$ = 12.3 m) en árboles o en postes. Tales perchas proveen un gran y relativamente no obstruido campo de vista y probablemente incrementan la probabilidad de detectar las presas. Los gavilanes de cola roja pasan mas tiempo en las perchas antes de atacar que antes de desistir, esperando quizás atacar las presas después de localizarlas para incrementar la probabilidad de un ataque exitoso. Las características de la vegetación alrededor de las perchas usadas por este gavilán para cazar, difirieron de aquellas áreas alrededor de sitios disponibles (y aparentemente sin uso) tanto durante la temporada reproductiva como no reproductiva. Durante la temporada reproductiva las áreas usadas por el gavilán de cola roja tenían menor cobertura de horquetas, una densidad de vegetación más baja, y vegetación más baja que en las áreas disponibles. Durante la temporada no reproductiva, las áreas usadas por los gavilanes se caracterizaron por un suelo menos desnudo, mayor cobertura de pastos, menor cobertura de arbustos, árboles pequeños más escasos, decrecimiento en la densidad de la vegetación y vegetación más corta que en las áreas disponibles. En general, las áreas usadas tenian menos cobertura, lo cual puede incrementar la vulnerabilidad de las presas.

[Traducción de César Márquez]

Red-tailed Hawks (*Buteo jamaicensis*) generally inhabit open areas with scattered trees used as hunting and roosting sites (Preston and Beane 1993). Perch sites are important components of Red-tailed Hawk territories (Fitch et al. 1946) because they are sit-and-wait predators (Craighead and Craighead 1956). Red-tailed hawks and other raptors may prefer certain perches over others (Fitch et al. 1946). For example, Bohall and Collopy (1984) found that both Red-tailed and Red-shouldered hawks (*Buteo lineatus*) preferred natural perches, mainly snags and bare trees, over man-made perches. In the autumn, Chamberlin (1974)

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reported that Red-tailed Hawks preferred to hunt from isolated trees at a height of 12.5–18.3 m. During the summer, Red-tailed Hawks may prefer lower perches that provide some shade (Fitch et al. 1946).

Despite the importance of perches, few investigators (Fitch et al. 1946, Chamberlin 1974, Bohall and Collopy 1984) have described perch site selection by Red-tailed Hawks. Little is known about the features of perches chosen by these hawks or the characteristics of used versus available perches. In addition, possible differences in the hunting behavior of these hawks among or between seasons have not been studied. The objectives of our study of Red-tailed Hawks were to: (1) determine the characteristics of selected perch sites and surrounding vegetation during the nonbreeding and breeding seasons, and (2) examine possible relationships between hunting behavior and the characteristics of perches and surrounding vegetation.

METHODS

Red-tailed Hawks were observed from October 1999–July 2000 at the Blue Grass Army Depot (BGAD), Madison Co., Kentucky. The depot encompasses 5907 ha and consists of open grassland interspersed with trees and small woodlots. We visited the BGAD 2–3 times a week during both the nonbreeding (October–March) and breeding (April–July) seasons. For each hawk observed that seemed to be hunting (scanning or looking in the direction of the ground rather than engaged in other activities such as preening or resting with eyes closed), we noted its location and, if observed landing on a perch, recorded the time spent on a perch until initiating an attack or "giving up" (changing perches or flying from the area). Once a hawk left the area, the perch substrate was identified (tree species or human-made substrate type) and marked. Perch and substrate heights were measured using a clinometer and the diameter at breast height (DBH) of the substrate measured with a DBH tape. If an attack occurred, the attack distance (measured from the perch site to the point of attack) was measured using a tape measure. Perch locations were recorded using a Global Positioning System unit (Garmin XLS, Garmin International, Olathe, KS), and these locations were used to determine distances between successive perches.

The habitat around perches was categorized as woodlot, woodrow (a strip of trees ≤30 m wide located along abandoned fencerows and streams), edge (within 5 m of the edge of a woodlot or woodrow), mowed field (open fields with vegetation ≤0.5 m high), or unmowed field (open fields with vegetation >0.5 m high). For statistical analysis, each habitat type was assigned a numerical value based on relative vegetation height and density (with density being our estimate of the relative density of tree trunks and branches) (mowed = 1, unmowed = 2, edge = 3, woodrow = 4, and woodlot = 5). If an attack was made, we recorded the attack distance (estimated distance from the perch to the attack site), outcome (successful or not), and, if possible, identity of the prey.

Twenty-five of 270 perches used by Red-tailed Hawks during the breeding and nonbreeding seasons, respectively, were randomly chosen and the surrounding vegetation characterized (James and Shugart 1970). In addition, 50 'perches,' that to our knowledge were not used, were randomly located during the breeding ($N = 25$) and nonbreeding seasons ($N = 25$), respectively. These perches (hereafter referred to as available perches) were identified using a random number table to select map coordinates. From that location, we again used a random number table to obtain a compass bearing, then a random number of paces (0–999) taken in that direction From that point, we selected the closest tree or human-made object that could support a Red-tailed Hawk (≥10 cm DBH). For both used and available perches, we identified the species of vegetation or other substrate type (e.g., utility pole) and measured the height and DBH Three 100-m long, 3-m wide belt transects starting at the base of the perch substrate were randomly chosen (with the only stipulation being that the transects lay within 90 degrees of either side of the direction the hawk was facing at that perch or within 90 degrees on either side of a randomly-selected direction for unused sites) using a random number generator to obtain a compass bearing At 10-m intervals along each transect, we noted the ground (bare ground, grass, forb, or shrub) and canopy cover (present or absent). The number of shrubs (<8 cm DBH) and trees (>8 cm DBH) was counted along the entire length of each transect. The density of grass and forbs was measured in 25-cm increments by passing a pole vertically through the vegetation and counting the number of vegetation contacts within an estimated 10 cm radius of the pole (Rotenberry and Wiens 1980). Vegetation height at each point was also determined.

To analyze data, the Statistical Analysis System (SAS Institute 1989) was used. Possible variation in the characteristics of perch sites and in hunting behavior (e.g., giving-up times) with season, outcome (attack or give up), and habitat was examined using repeated-measures analysis of variance. Because three analyses were conducted, we used a Bonferroni-adjusted alpha level of 0.017. Hawks were not captured and individually marked However, for the repeated-measures analysis, those observed in particular areas were assumed to be the same individual. These areas were delineated by plotting the movements of hawks on a map of the study area. Because of occasional trespassing by neighboring individuals, the movements of migrating individuals, and possible overlap in the hunting ranges of breeding pairs, it is likely that Red-tailed Hawks other than the presumed resident individual were sometimes observed in particular areas.

All variables were tested for heterogeneity of variances and for normality. Variables that did not meet the assumptions of homoscedasticity and normality were log-transformed prior to analysis. Mean values of used and available perches were compared using multivariate analysis of variance. Wilcoxon tests were used for univariate comparisons. Stepwise discriminate analysis (backward procedure) was used to identify variables that best discriminated ($P < 0.05$) among used and available perch sites and sites used during breeding and nonbreeding

Table 1. Vegetation characteristics of perches used by Red-tailed Hawks versus available perches during the breeding season.

VARIABLE	USED[a]		AVAILABLE[b]		WILCOXON TEST
	MEAN	SE[c]	MEAN	SE[c]	*P* VALUE
Percent bare ground	8.6	1.9	7.5	1.4	0.91
Percent grass cover	86.0	3.0	81.0	2.0	0.07
Percent forb cover	2.2	0.5	5.1	0.9	0.02
Percent shrub cover	3.3	1.3	6.2	1.8	0.12
Percent canopy cover	9.0	2.0	15.0	1.0	0.01
Number of small trees	9.3	1.9	21.2	6.2	0.11
Number of large trees	2.8	0.7	7.7	1.3	0.01
Number of bushes	322.0	89.1	320.1	85.6	0.99
Vegetation contacts (<25 cm)	49.7	14.0	145.4	26.2	<0.01
Vegetation contacts (25–75 cm)	60.8	24.8	84.8	23.3	0.04
Vegetation contacts (>75 cm)	12.3	5.7	49.9	22.1	0.01
Vegetation height (cm)	20.0	2.0	34.0	4.0	0.02

[a] $N = 25$, except for the variable number of bushes ($N = 21$).
[b] $N = 25$.
[c] Standard error.

seasons, respectively. The cross-validation technique was used to evaluate model classification efficacy (Williams et al. 1990). Cohen's *Kappa* and its *Z* value were calculated to test model performance (Titus et al. 1984). All values reported are means ± SE.

RESULTS

Red-tailed Hawks used 270 hunting perches on 31 different types of substrates, with black locusts (*Robinia pseudoacacia*; $N = 58$), sycamores (*Platanus occidentalis*; $N = 45$), utility poles ($N = 40$), and black cherries (*Prunus serotina*; $N = 37$) used most often. Of the 50 randomly-chosen perches, 11 were black cherries (22%), 10 black locusts (20%), seven sycamores (14%), and seven white ashes (*Fraxinus americana*; 14%). Most used perches were in mowed fields ($N = 153$, 49.2%). Perches were used an average of 1.17 ± 0.03 times ($N = 269$). Mean perch height was 12.3 ± 0.3 m (range = 3.5–32.5 m; $N = 262$), while mean substrate height was 18.7 ± 0.4 m (range = 6.8–37.4 m; $N = 316$). The mean DBH of perch substrates was 44.2 ± 1.2 cm (range = 13.1–124.9 cm; $N = 279$). Mean time on perches was 8.6 ± 1.0 min (range = 0.2–151 min; $N = 284$) and Red-tailed Hawks flew a mean distance of 136.4 ± 18.9 m (range = 1–990 m; $N = 74$) to subsequent perches. Only seven attacks were observed, with Red-tailed Hawks capturing two small mammals and five unknown prey items.

Neither giving-up time ($F_{3,48} = 0.17$, $P = 0.91$) nor perch height varied ($F_{3,50} = 0.15$, $P = 0.93$) with habitat type. In contrast, the mean time spent on perches by Red-tailed Hawks differed with outcome ($F_{1,21} = 7.87$, $P = 0.01$), with a mean perch time of 23.9 ± 12.4 min ($N = 7$) before attacks and 5.1 ± 0.5 min ($N = 214$) before giving up.

Because Red-tailed Hawks may reuse perches with particular characteristics, we compared the characteristics of perches used once to those used more than once. Analysis revealed no differences in substrate height ($F_{1,27} = 0.44$, $P = 0.51$), DBH ($F_{1,27} = 1.48$, $P = 0.23$), or habitat type ($F_{1,27} = 2.71$, $P = 0.15$).

Used Versus Available Perches. The mean height and DBH of used and available perches did not differ ($F_{1,17} < 1.14$, $P \geq 0.30$). In addition, used and available perches were located in similar habitats ($F_{1,17} = 0.13$, $P = 0.72$).

The characteristics of perches used by Red-tailed Hawks differed from available perches in both the breeding (Wilk's Lambda = 0.50, $F_{11,38} = 3.42$, $P = 0.002$) and nonbreeding (Wilk's Lambda = 0.33, $F_{11,39} = 7.29$, $P < 0.001$) seasons. For the breeding season, univariate tests revealed that seven vegetation variables differed ($P < 0.05$; Table 1), and stepwise discriminate analysis identified three characteristics that best discriminated between used and available perches during the breeding season: percent canopy cover, number of large trees, and

Table 2. Vegetation characteristics of perches used by Red-tailed Hawks versus available perches during the nonbreeding season.

VARIABLE	USED[a]		AVAILABLE[b]		WILCOXON TEST
	MEAN	SE[c]	MEAN	SE[c]	*P* VALUE
Percent bare ground	3.9	1.3	13.0	3.2	<0.01
Percent grass cover	84.0	4.0	72.0	4.0	0.01
Percent forb cover	5.5	1.6	7.0	1.9	0.56
Percent shrub cover	1.0	0.5	6.8	1.5	<0.01
Percent canopy cover	16.0	2.0	20.0	2.0	0.08
Number of small trees	4.4	2.6	51.3	16.6	<0.01
Number of large trees	4.9	1.0	10.4	2.8	0.42
Number of bushes	112.5	18.5	136.7	40.3	0.94
Vegetation contacts (<25 cm)	9.3	7.3	59.4	12.9	<0.01
Vegetation contacts (25–75 cm)	12.7	10.3	61.1	17.9	<0.01
Vegetation contacts (>75 cm)	5.6	3.8	46.7	13.1	<0.01
Vegetation height (cm)	9.0	3.0	33.0	5.0	<0.01

[a] $N = 26$, except for the variable number of bushes ($N = 2$).
[b] $N = 25$, except for the variable number of bushes ($N = 14$).
[c] Standard error.

number of vegetation contacts below 25 cm. Analysis using these three variables correctly classified 92% of used perches and 80% of available perches (72% better than by chance alone; Cohen's *Kappa* $Z = 5.14$, $P < 0.01$).

Univariate tests revealed eight vegetation variables that differed ($P < 0.05$) during the nonbreeding season (Table 2). Stepwise discriminate analysis identified six characteristics that best discriminated between used and available perches during the nonbreeding season: percent bare ground, percent grass, percent shrub, number of vegetation contacts lower than 25 cm, number of vegetation contacts between 25 and 75 cm, and vegetation height. Analysis using these variables correctly classified 84.6% of used perches and 80% of available perches (71% better than by chance alone; Cohen's *Kappa* $Z = 6.51$, $P < 0.01$).

Seasonal Differences in Perch-site Characteristics. Red-tailed Hawk perch height did not vary with season, with a mean of 12.9 ± 0.9 m for the breeding season and 12.2 ± 0.3 m for the nonbreeding season ($F_{1,27} = 2.96$, $P = 0.097$). Also, the mean distance flown to subsequent perches during the breeding ($\bar{x} = 122.6 + 27.8$ m; $N = 15$) and nonbreeding ($\bar{x} = 143.1 \pm 24.9$ m; $N = 53$) seasons did not differ ($F_{1,28} = 0.01$, $P = 0.95$). Habitat surrounding perches did not vary ($F_{1,27} = 0.63$, $P = 0.43$) by season, with most perches located in mowed fields throughout the study. Differences between seasons in giving up times approached significance ($F_{1,28} = 4.66$, $P = 0.04$), with a mean giving up time of 20.8 ± 4.4 min ($N = 52$) for the breeding season and 5.8 ± 0.6 min ($N = 215$) for the nonbreeding season.

DISCUSSION

Red-tailed Hawks in our study used natural perches more than human-made perches such as utility poles, and similar results have been reported by others (Chamberlin 1974, Bohall and Collopy 1984, Bildstein 1987). Although human-made structures may provide suitable perches for raptors, the number and distribution of such structures may not be sufficient in most areas to provide access to all available hunting areas. Most perches used by Red-tailed Hawks in our study were in black locust and sycamore trees, and on utility poles. The frequent use of black locust and sycamore trees on the BGAD (38% of all perches) was likely related to abundance, with these two species comprising 34% of the 50 available trees. In addition, however, both trees have open crowns (Elias 1980), which may provide easier access to perches for Red-tailed Hawks.

The absence of utility poles in our random sample indicates that utility poles were not as abundant on the BGAD as many trees. Where available, however, Red-tailed Hawks may prefer utility poles as perches because they provide ready access and an

unobstructed view. Errington and Breckenridge (1938) also noted the use of poles and fence posts by hawks in the genus *Buteo*. Similarly, Ferruginous Hawks (*Buteo regalis*) used fence posts (Wakeley 1978, Plumpton and Andersen 1997) and other man-made substrates (Plumpton and Andersen 1997) as perches more than other substrates.

Red-tailed Hawks in our study perched at a mean height of 12.3 m. Similarly, Craighead and Craighead (1956) and Bildstein (1987) found that Red-tailed Hawks typically perched at heights of 11.0 m and 11.3 m, respectively, while Chamberlin (1974) found that perches were usually between 12.5–18.3 m high. Craighead and Craighead (1956) stated that buteos choose high, conspicuous perches to scan an area. Higher perches may provide a larger field of view (Sonerud 1992) and increase chances of detecting prey. However, prey detectability decreases as perch height increases (Andersson 1981), and higher perches also increase attack distance and the chance that potential prey will see an attacking hawk and avoid capture. For example, hunting success declined with increased attack distance in Ferruginous Hawks (Wakeley 1978). Thus, Red-tailed Hawk perch heights may represent a compromise between the need to scan as much area as possible while minimizing attack distances.

From 270 perches, Red-tailed Hawks in our study initiated only seven attacks. Chamberlin (1974) observed Red-tailed Hawks for three months in Michigan and observed just 16 attacks, with five being successful. Bildstein (1987) reported observing only 14 attacks by Red-tailed Hawks over four months in southern Ohio. Such results suggest Red-tailed Hawks initiate attacks at low rates. Preston and Beane (1993) noted that Red-tailed Hawks were opportunistic predators that focused on the largest prey readily available. This tendency, in combination with a high percentage of successful attacks (Orde and Harrell 1977), suggests that few attacks might be needed to meet a hawk's energetic needs, perhaps contributing to the low attack rates observed in our study and previous studies.

Red-tailed Hawks spent more time on perches before an attack than before giving up. Although this difference should be viewed with caution because we only observed seven attacks, investigators have also reported longer attack times than giving-up times in other raptors. For example, Bye et al. (1992) found that attack (or detection; Carlson 1985) times of Boreal Owls (*Aegolius funereus*) averaged 4.55 min and giving-up times 2.23 min. Similarly, Sonerud (1989) noted that attack times were longer than giving-up times for Northern Hawk Owls (*Surnia ulula*). In contrast, giving-up times were longer than attack times for American Kestrels (*Falco sparverius*; Rudolph 1982) and two passerines, Eastern Bluebirds (*Sialia sialis*; Pinkowski 1977) and Spotted Flycatchers (*Muscicapa striata*; Davies 1977). The type of prey being hunted may contribute to these differences. Because mammals are more difficult to capture than insects (Temeles 1985), predators hunting mammals may wait longer before initiating an attack. For example, hawk owls wait to attack their prey after locating it to make sure it is uncovered to increase the chance of a successful attack (Sonerud 1992).

Perch-site Preference: Used Versus Available Perches. During the breeding season, hunting areas used by Red-tailed Hawks in our study had less forb cover, less dense vegetation (fewer vegetation contacts) in all three height categories, and shorter vegetation than available areas. In Arkansas, Preston (1990) found that habitat patches with greater plant cover density (e.g., tall corn and wetlands) supported greater prey biomass than patches with less cover (e.g., old fields and corn stubble). Despite such differences, Red-tailed Hawks favored old field and corn-stubble patches (Preston 1990). Other investigators have also noted that Red-tailed Hawks typically forage in areas with less cover (Craighead and Craighead 1956, Orde and Harrell 1977). With less ground cover, Red-tailed Hawks may be able to see and capture prey easier (Baker and Brooks 1981). Orde and Harrell (1977) suggested that Red-tailed Hawks preferred areas with vegetation less than 10 cm high because this increased prey vulnerability. Similarly, Preston and Beane (1996) reported that Red-tailed Hawks favored areas with sparse ground cover and, presumably, high prey vulnerability.

Hunting areas used by Red-tailed Hawks in our study were also more open than available areas, with less canopy cover and fewer large trees. Similarly, other investigators have noted that Red-tailed Hawks are typically found in more open areas than sympatric Broad-winged (*Buteo platypterus*) and Red-shouldered (*Buteo lineatus*) hawks (Titus and Mosher 1981, Bednarz and Dinsmore 1982). Because of their relatively large size (and wingspan) and apparent preference for open areas for hunting, Red-tailed Hawks may avoid areas with high densities of trees.

During the nonbreeding season, hunting areas

used by Red-tailed Hawks in our study had less bare ground, more grass cover, less shrub cover, fewer small trees, less dense vegetation, and shorter vegetation than available areas. As during the breeding season, shorter, less dense vegetation may make it easier for the hawks to locate and capture prey.

Perch-site Characteristics and Seasonal Differences. The hunting behavior of Red-tailed Hawks (perch height, distance between successive perches, and habitat used) did not vary with season, perhaps because hawks probably hunt similar prey in the same habitats throughout the year in our study area. Raptors whose food habits change with season may vary their behavior. For example, American Kestrels used lower perches when hunting insects than when hunting mammals (Bildstein 1987).

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